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ABSTRACT

This paper on science instruction for learners with mental disabilities reviews the limited literature base in the field and provides practical information on teaching science in special settings. To assist in implementing best instructional practices in science education, the paper discusses the curricular make-up of science instruction; various instructional approaches, programs, and strategies for teaching science to special learners; and selected instructional and resource materials. The advantages and disadvantages of various approaches to teaching science are presented, discussing textbooks, process/inquiry programs, specialized programs, customized programs, and eclectic approaches. A section on instructional strategies focuses attention on: the components of a science lesson, integration of other subject and skill areas into science, specific learning strategies that can help students, safety in the science classroom, use of microcomputers, ways to make the classroom "sciency," and recommendations for acquiring requisite laboratory materials and equipment. Four tables are provided. (JDD)

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Chapter Sixteen

Science

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OVERVIEW

Of all of the subject areas that are taught to students, science may be one of the most intriguing as well as one of the most feared by many teachers. For some students this subject area may be the most relevant part of their school day. On the other hand, depending on how it is taught, it could also be one of the most boring aspects of students' curriculum.

Rossman (1983) provides an excellent example of how science can be real to students. His example involved a "teachable moment" which occurred at the beginning of a science lesson with a group of fourth graders. Without warning, one of the students "cut the cheese" and the group responded in a predictable fashion. Rossman abandoned his planned lesson on fossils and immediately pursued this opportunity to discuss the reality of digestion. Many of the components of excellent science instruction subsequently took place.

This chapter will attempt to convey the enthusiasm and challenge of teaching science to students who have learning-related problems. The first section provides a basis for teaching science to special populations, highlighting what the literature says about this topic. The next section, the crux of this chapter, provides practical information related to curriculum, instruction, programs and materials, general suggestions for teaching this subject, and a list of resources. The chapter concludes with some final comments about where to go from here.

BASIC CONSIDERATIONS

Background

Most students are very curious about the world in which they live, often resulting in a natural interest in learning more about their respective environments. When teachers share this same enthusiasm the stage may be set for some fascinating learning.

Science and its sibling, social studies, have often been depicted as "second class subjects." This statement does not imply that they are not important areas of the curriculum; however, more attention has been given to other subjects such as reading, language arts, and mathematics. This is particularly true for special learners. In a study conducted by Patton, Polloway, and Cronin (1986), it was found that a significant number of students in special education programs were not receiving any science instruction at all.

It seems that many special education teachers do not feel comfortable teaching science. This may be due to a number of reasons. First and foremost is that few teachers receive adequate training in this area. Patton and colleagues (1986) found that nearly 42% of the special education teachers surveyed received no training of any type. A second factor which is related to the first one is that many teachers have very little experience teaching this subject, thereby increasing their reluctance to do so. Another concern voiced by teachers is that they are insecure about the content of science. To be sure, there is always some apprehension about being asked questions which you do not know the answers. Nevertheless, this concern can be

addressed and should not prevent teachers from teaching science. For the most part one has to become comfortable with the reality that you will not have the answers to every question and therefore must be ready to turn such situations into a challenge for both the student and the teacher.

The value of science instruction for special learners can be argued for many of the same reasons that it would be for students who are not experiencing learning-related problems. Ditchfield (1987) provides a strong case for teaching science to any student: "As a means of studying the world around us, and making sense of it, science has much to offer as way of working. It begins by asking questions . . . and develops into posing hypotheses, testing out such hypotheses by experiment and interpreting the outcomes" (p. 37). A few other reasons are listed below:

1. Science activities can broaden and enrich the experience base of students.

2. Special learners can benefit from activities which are based on reality and have predictable outcomes.

3. Manipulation of concrete objects can facilitate conceptual learning.

4. Science activities can involve the learning of cause and effect relationships.

5. There are many opportunities to develop and refine thinking and problem solving skills.

It is also important to understand that there are three major goals implicit in science education: content/ knowledge, skills, and attitudes. First, there is a certain amount of information in the areas of life, physical, and earth science which needs to be covered. Second, and just as important as the content goal, is the development of various inquiry skills which are related to the study of science. Interestingly, these inquiry skills are useful in other areas of the curriculum as well and will be discussed later in this chapter. The last goal involves the creation of a scientific attitude which is best explained as a "need for seeking rational answers and explanations to natural and physical phenomena" (Cain & Evans, 1984, p. 9). All three of these goals should be considered in the development of science programs for learners.

Review of the Literature

There is a paucity of literature on the teaching of science to special populations. What is available is mostly descriptive rather than empirical. Although this is changing, there still is very little research which has been conducted in this area. In general, professionals who have written about science education for special learners argue that it should be given more attention. Unfortunately, it is still very difficult to determine the current status of science instruction for students with learning problems. In one of the few studies to try to examine the present state of affairs, Patton and associates (1986) noted some trends:

1. A significant number of students are not receiving science instruction (e.g., 38% of the self-contained classes);

2. many students with mild disabilities in mainstreamed settings for science;

3. of those teachers who do teach science, nearly half devote less than 60 minutes per week;

4. special education teachers generally utilize regular education curricular sequences;

5. relative infrequent use of science materials which are specifically designed for students with disabilities;

6. nearly 60% of the teachers surveyed used a regular education textbook; and

7. very few teachers have received training in how to teach science.

A few studies have been conducted which seem to indicate that certain programs have been successful with special learners (Ball & Danglade, 1978; Davies & Ball, 1978; Esler, Midgett, & Bird, 1977; Menhusen & Gromme, 1976; Wilson & Koran, 1973). It is curious that so few studies have been conducted and the ones that have been are becoming dated. A few years ago, Frith and Mitchell (1980) highlighted the need for more conclusive evidence which would validate the efficacy of science education for special populations. To date, not much has happened.

Some research has been done which focuses on particular instructional techniques. For instance, Lovitt and colleagues (Lovitt, Rudsit, Jenkins, Pious, & Benedetti, 1985; Lovitt, Rudsit, Jenkins, Pious, & Benedetti, 1986) have examined the effects of modifying a physical science textbook for seventh grade students. In a different line of research, Scruggs, Mastropieri, and their associates (Mastropieri, Scruggs, McLoone, & Levin, 1985; Scruggs, Mastropieri, Levin, & Gaffney, 1985; Scruggs, Mastropieri, McLoone, Levin, & Morrison, 1987) have studied the use of mnemonic techniques in the acquisition of science facts.

Another area which has received limited attention yet is very important is the nature of science education for students with mild disabilities who are mainstreamed into regular education science classes. The little information that does exist in this area typically includes recommendations and suggestions for helping students (c.f., Patton & Andre, 1989; Schulz & Turnbull, 1983) but no indication of how these pupils are doing.

Traditional Teaching Methods

Think back and try to recollect what your elementary science education was like. For many of us, it consisted of a textbook exclusively with very little hands-on involvement. The usual scenario was read the chapter, define the vocabulary words which were listed at the beginning of the chapter, and answer the questions which were presented at the end of the chapter. It is a wonder why any of us chose science as a college major.

Heavy reliance on textbooks as the primary vehicle for delivering science instruction was commonplace in the 1950s. After the Soviet Union launched Sputnik in 1957, there was a wholesale revamping in the way educators thought

science should be taught. As a result, in the early 1960s a number of major federally-funded science curriculum projects were initiated. The goal was to develop programs which emphasized inquiry and process rather than content. By the end of the decade and into the 1970s, these newly developed programs were promoted and their implementation was begun in many schools around the nation. It is quite clear that these programs had a major impact on science instruction by encouraging a more "hands-on" character. This influence could be witnessed in the evolution of more laboratory-oriented textbook series of recent years. Recently, there seems to be a trend back to the former emphasis on content acquisition through the use of textbooks in some areas of the country (see Bindel, 1985).

For the most part, there seems to be five identifiable approaches to teaching science. All of them can be appropriate for use in special settings and will be discussed later. These orientations include (a) textbook, (b) process/inquiry programs, (c) specialized programs, (d) customized programs, or (e) eclectic approach.

BEST PRACTICES

This section is devoted to presenting practical information which is immediately useful in classroom situations. It is divided into four parts. The first subsection examines the curricular make-up of science instruction. The second subsection highlights various instructional approaches, programs, and strategies for teaching science to special learners. The next subsection presents selected instructional materials which teachers should find useful. The last subsection offers lists of promising resource materials that may be extremely helpful.

Before getting into the bulk of this section, it seems worthwhile to identify some guiding principles for teaching science to special populations. It is suggested that teachers keep the following ideas in mind:

1. Make your science instruction activity-oriented;
2. attempt to relate science topics to the students' everyday experiences;
3. choose a curriculum that is interesting to the students and to you;
4. consider the linguistic and conceptual demands of the curriculum as some students may have great difficulty with these areas; and
5. establish an efficient system of managing your classroom, paying particular attention to establishing sound rules and procedures for your science period.

Curricular Considerations

There is no one curricular sequence in science. As mentioned earlier, most elementary and secondary science courses are elements of or entirely devoted to one three components: life science (the study of living things including zoology, botany, ecology); physical science (the study of nonliving things including chemistry, physics); and earth science (astronomy, meteorology, geology).

To understand what a K-6 curricular sequence might look like, a list of the major topics covered in a popular textbook series is presented below. The series selected is the Addison-Wesley Science program.

K:
- Health & Safety
- Animals
- Weather
- Our Senses
- Everyday Things
- Water
- Moving Things
- Earth Beneath Our Feet
- Plants
- Foods

1:
- Animal Needs
- Plant Needs
- Pushes and Pulls
- Water and Ice
- Air
- Light
- Time
- Shells
- Growth
- Your Body
- Space for Things
- Soil

2:
- Seeds
- Living Things in Fall and Winter
- Standard Units
- Weather
- Food and Your Health
- Matter
- Particles
- Sound
- Work and Energy
- Traces of Living Things
- Living Things in Spring
- Energy from the Sun

3:
- Communities of Living Things
- Measurement - A Science Process
- Motion & Location
- Air - An Invisible Push
- Bones and Muscles
- Shadows and Light
- Sunlight on the Earth and Moon
- Heat and Temperature
- It All Depends!

4:
- Life Cycles
- Water and the Land
- Electric Light Circuits
- Cells, Tissues, & Your Body
- Sliding, Rolling, & Friction
- Air Around Us
- Stars - Night and Day
- Vibrations and Sounds
- Ocean and Freshwater Environments

5:
- Classifying Living Things
- Rocks in Layers
- Changes in Matter
- Your Nutrition and other Needs
- Magnets and Their Uses
- Winds and Convection
- Paths of Light
- Forces and Motion
- The Moon - Our Nearest Neighbor
- Interdependence of Living Things

6:
- Changing and Preserving Our Environments
- Water in the Air
- Images and Refraction
- Earth in Space
- Electric Charges and Currents
- Using Forces
- Changes in the Land
- Living Things - Continuity and Change
- Populations
- Energy and Energy Problems

This topical sequence is only illustrative and is not meant to represent the majority of curricular sequences found at the elementary level. Upon examination of the various topics covered, it is clear that the three major areas of science discussed above are addressed. (For a tabular comparison of five major textbook series and the topics they cover, see Polloway, Patton, Payne, & Payne, in press).

Evolving out of the philosophy of science education prevalent in the late 1960s and 1970s came a heightened awareness of the importance of certain skills associated with the process of science education. These skills, commonly referred to as inquiry skills, are typically integrated into science programs. Regardless of which approach a teacher chooses to follow in providing science education to special learners, the incorporation of these skills into instruction is strongly recommended. The most important inquiry skills and accompanying descriptions (Cain & Evans, 1984, pp. 8-9) are provided below:

1. Observation: using the senses to find out about subjects and events

2. Classification: grouping things according to similarities or differences

3. Measurement: making quantitative observations

4. Communication: using the written and spoken word, drawings, diagrams, or tables to transmit information and ideas to others

5. Data Collection, Organization, & Graphing: taking quantitative data and making sense out of it, primarily through graphic techniques

6. Inference: explaining an observation or set of observations

7. Prediction: making forecasts of future events or conditions based upon observations or inferences

8. Data Interpretation: finding patterns among sets of data that lead to the construction of inferences, predictions, or hypotheses

9. Formulation of Hypotheses: making educated guesses based on evidence that can be tested

10. Experimentation: investigating, manipulating, and testing to determine a result

To help appreciate how these skills can be integrated into science activities, an example is presented in Table 1. This example comes from a science unit that was implemented recently with 4th and 5th grade students. The general topic being studied was marine biology and the specific subtopic under study was a reef organism known as a hermit crab. The Table demonstrates only some of the many examples of inquiry skills being utilized in this series of activities designed for this unit.

Table 1

Examples of Inquiry Skills

INQUIRY SKILL	HERMIT CRAB ACTIVITY
Observation	Identification of body parts
Measurement	Timing of crab races
Classification	Species identification
Communication	Description of habitat poetry
Data Collection, Organization & Graphing	Shells preferred by crabs
Inference	How crab attaches to inside of shell
Prediction	Location/Movement of crabs as a function of time of day and tides
Data Interpretation	Conclusions derived from information collected (e.g., species data)
Hypothesis Generation	Generation of ideas about how often crabs change shells based on growth patterns
Experimentation	How crabs will react to changes in their habitats

Instructional Programs

The focus of this section is to provide teachers with specific ideas for designing science programs for special learners. Topics to be covered include the advantages and disadvantages of the various approaches to teaching science as well as a brief description of some commercially available programs.

There are attractions and hindrances to all of the major approaches. Table 2 summarizes the features and gives examples of each approach to science instruction. Each of these will be discussed in some detail below.

Textbook Approach

Textbooks still play a crucial role in the science education of many students. This becomes even more pronounced as students enter the upper elementary grades (Teters, Gabel, & Geary, 1984). Patton and associates (1986) in their study of mildly handicapped classes found that approximately 60% of the teachers they contacted used a regular text in some way.

As Table 2 highlights, there are some persuasive reasons for using a textbook; leading the list of potential problems is the readability issue. Most of the current textbook series now come with laboratory kits, recognizing the need for more hands-on activities. Certain series, most notably the Addison-Wesley Science and Houghton-Mifflin Science have made a concerted effort to deemphasize the need to have good reading skills to enjoy and learne science. Another recent development is publication of secondary-level science materials which are designed for students with low reading levels (e.g., publications from Quercus and Project Earth).

Using textbooks requires that students be able to comprehend content that may be difficult to understand at times. Carnine and Silbert (1979) identified four areas which should be examined in helping students comprehend science textbooks: vocabulary level; content - in terms of the conceptual complexity; writing style and organization; and special features such as graphics and illustrations. It may be necessary to augment the textbook with additional activities to help students better grasp the concept being addressed.

Process-Oriented Approach

The second major approach to teaching science is to employ commercially-available process-oriented programs. Although these programs were developed for use in regular education, their implementation in special settings is warranted. This type of approach can be characterized as stressing skills over the accumulation of substantive information, accentuating doing and discovery, and involving teachers as facilitators. Table 2 lists the strengths and weaknesses of this approach. Three of the most widely used programs are briefly described below:

1. Elementary Science Study (ESS):
   Publisher: McGraw-Hill
   Grade Range: K-9
   Features: 56 individual units
   flexibility -- units can be used at different grade levels
   activity-oriented
   provisions for special students

2. Science Curriculum Improvement Study (SCIS/SCIIS):
   Publisher: Rand McNally
   Grade Range: K-6
   Features: 13 units (one for K; two for each grade level)
   complete science program
   emphasis on concept of "interaction"

3. Science -- A Process Approach:
   Publisher: Ginn and Company
   Grade Range: K-6
   Features: 15 modules per grade level
   sequence should be followed

Table 2

Analysis of Various Approaches [Source: Wood (1989)]

	ISSUES RELATED TO SPECIAL LEARNERS		
APPROACH	POSITIVE FEATURES	NEGATIVE FEATURES	REMARKS
TEXTBOOKS	*organized science program *useful for beginning teachers *excellenct resources *certain series contain many hands-on activities *teacher's guide may contain suggestions for working with special learners *most textbook series come with material kits	*readability problems *geared for average students *can be too content-oriented *may become only source of information *contents may be covered too quickly *content often presented apart from activities	*certain services have de-emphasized the need to have good reading skills [Addison-Wesley Science and Houghton-Mifflin Science *checklists exist to help teachers evaluate textbooks [see Cain & Evans, 1985; Price, Ness, & Stitt, 1982 *newly published texts of high interest, low readability are now available
PROCESS/ LABARATORY PROGRAMS	*stress inquiry/problem solving *minimize the need to be a good reader *activity-oriented *curricularly flexible *can be used with older students	*may be too discovery-oriented for some students *less teacher-directed instruction which some special students may require *require special instructional skills which not all teachers demonstrate or are comfortable with *may not address concept development appropriately for some students	*with some modification these programs can work with special groups *can be effectively used in combination with other programs *some of these programs have developed additional materials for working with special populations, e.g., ESS/ Special Education Teachers Guide [Ball, 1978]
SPECIALIZED PROGRAMS	*developed with special population in mind *minimize reading skills *programs designed for older students are functionally-oriented	*may not cover some important science topics *may differ from a school system's other science programs *probably will be used in non credit generating courses	*there are relatively few programs of this nature currently available *little empirical research exists validating their value *activities from these programs can be integrated into regular science program
CUSTOMIZED PROGRAMS	*can be based on interests, current issues, local needs *relevant *typically very "hands-on"	*requires much teacher time *may not cover some important science topics *may not match the scope and sequence of the school system *may not address concept development appropriately	*success depends on the following qualifies of the teacher *resourcefulness *organizational skills *instructional skills *curriculum development abilities *for older students this approach may be warranted to better prepare them for adulthood

It is the personal view of this author that programs such as these can be used effectively with special learners. However, approaches do require a different type of instructional role for teachers. It is essential that special education teachers do the following:

1. Become very familiar with the units/topics/modules.

2. Focus on preparation--if some modification is necessary, do it ahead of time.

3. Be prepared to provide more structure to the activities than is typically called for (e.g., specially-designed data collection sheets and/or graph paper).

4. Become comfortable with the role of facilitator through practice and experience.

Specialized Programs

The third type of approach to teaching science to learners with various disabilities is to employ specialized programs and materials which were purposely designed for these students. Table 2 contains information on the general features of such programs. The truth of the matter is that there are very few programs available and those that are may or may not be suitable to the needs of some special education settings. Furthermore, convincing empirical evidence as to the effectiveness of these programs is needed. Four programs are briefly outlined below:

1. Me Now:
   Publisher: Hubbard Scientific Company
   Grade Range: upper elementary
   Target Group: students with mild mental disabilities
   Features: life science program -- four units
   activity-oriented
   two year sequence
   activities -- small, discrete units
   reading minimized
2. Me and My Environment:
   Publisher: Hubbard Scientific Company
   Grade Range: junior high school
   Target Group: students with mild mental retardation
   Features: environmental science program -- five units
   three year sequence
   activity-oriented
   relevant to everyday life
3. Me in the Future:
   Publisher: Biological Sciences Curriculum Study
   Grade Range: high school
   Target Group: students with mild retardation
   Features: integration of science and career education - three areas/units
   adult interest level
   low readability level

4. Science Enrichment for Learners with Physical Handicaps (SELPH):
   Publisher: Center for Multisensory Learning (Lawrence Hall of Science, University of California, Berkeley)
   Grade Range: upper elementary
   Target Group: students with learning problems
   Features: life and physical science program -- nine modules
   multisensory and activity-oriented
   best used as supplemental program

Customized Approach

The next approach to be discussed is the customized program. This type of program is designed and developed completely by the teacher or team of teachers. The features of this approach are also presented in Table 2. Much time and certain skills are required to effectively develop one's own curricula. Anyone interested in pursuing program development should consult with the local school systems' science scope and sequence chart, examine commercial programs, and check out the instructor's manual from any of the Hubbard materials described in the previous paragraphs as these manuals contain a useful discussion on developing science curricula.

Eclectic Approach

The last orientation, although not listed in Table 2, is the eclectic approach. This seems to be a very popular way of teaching science as it capitalizes on many of the features of the different approaches discussed above. Many teachers have found that integrating a textbook series with activities and ideas from the other approaches provides them with a sound, comprehensive, and engaging science program.

Instructional Strategies

This section will cover topics which are directly related to what happens in the classroom. Specifically, attention will be given to the major parts of a science lesson, integrating other subject and skill areas into science, specific learning strategies that can help students, safety in the science classroom, use of microcomputers, ways to make the classroom "sciency", and recommendations as to what laboratory materials and equipment might be useful.

Components of a Science Lesson

Science lessons differ due to the major objectives to be accomplished and the nature of the activities to be performed. However, every lesson should be planned to accommodate individual differences and organized in advance. There are three major parts of every lesson: opening activities, main instructional activities, and closure activities.

1. Opening activities: This part of the lesson should do two important tasks. It should clarify to students what is to happen and attempt to engage them in the topic at hand. This latter goal can be accomplished through the use of an opening demonstration, by asking a provocative question, or capitalizing on a teachable moment like flatulation.

2. Main instructional activities: This part of the lesson is the actual "hands-on" part. It might require students to do something using any number of inquiry skills in the process and then for them to collect and organize data related to this activity. Subsequent to this, students will then have to make sense of what they have done.

3. Closure Activities: In closing the science period each day, it is important that students review what they have done, understand what they may have learned (i.e., relate to the real world), evaluate their performance, and be prepared for the next day's lesson.

As Polloway, Payne, Patton, and Payne (1985) note: "Following these major components of a science lesson, teachers can provide a certain structure to their lesson planning that is useful to them and helpful to their students (p. 348)."

Integrating Science with Other Subject/Skill Areas

Using science as the backdrop, many other subjects and skills can be interwoven in creative ways. Obviously, reading skills may be requisite for many science programs; however, it is relatively easy to incorporate other areas as well. A few selected examples will help to get this idea across.

1. Mathematics: It is actually difficult not to include math in the study of science. Many of the inquiry skills can involve the use of various math skills. For instance, in the hermit crab example (Table 1) measurement and computational skills are used throughout this unit. There is a commercial program which focuses entirely on this relationship between math and science (Project AIMS--"Activities for Integrating Mathematics and Science").

2. Music: One of the products of the unit on marine biology mentioned earlier was a "rap" song. The students generated the lyrics and then these lyrics were put to music using a pre-programmed rhythm device. Part of the song went like this:

> "There's a creature called sea anemone,
> That we studied in marine biology."

3. Art: In a science unit entitled "Appliance Science" in which students took apart broken household appliances and studied how they worked, it was very easy to extend this unit to include art activities. For instance, when old phones were dismantled, the many internal parts provided more than enough material to develop robots, spaceships, and many other creations.

4. Careers: Almost every science topic that is covered lends itself to the study of jobs, hobbies, and recreation. For example, the Elementary Science Study unit on "Clay Boats" which examines bouyancy can lead into a number of interesting adjunct topics related to different vocations and leisure time pursuits.

It is also possible to design an entire curriculum around the idea of integrating subject and skill areas. For instance, using a science theme as the foundation of the curriculum (i.e., ants), Nakashima and Patton (1986; in press) integrated all other subject areas into this broad-based theme of interdependence. This type of programming which is often used with high potential students has merit for use with other groups as well. However, basic skill development and remediation will often have to be part of the instructional program for most students with learning-related problems. For older students, this type of programming might be beneficial as it ties topics together through the emphasis on integration.

Specific Learning Strategies

All of the techniques associated with effective instruction are appropriate for use in science programs for special learners. Certain strategies have been suggested as particularly valuable and will be mentioned in this section.

If it becomes necessary to adapt science materials, teachers should strive to keep the changes at a minimum. Care should be taken so that changes made do not alter the concept being addressed. Lovitt and colleagues' (1985, 1986) adapted a seventh grade physical science textbook. Some of the adaptations which they made included structured outline formats and vocabulary practice sheets. These external learning aids were found by the researchers to enhance student performance.

If the intent is for students to remember factual information and if these students have problems in producing effective learning strategies for doing so, then teaching them certain strategies may prove helpful. Mastropieri and Scruggs (1987) suggest the use of transformational mnemonic illustrations (e.g., keywords or pegwords). These techniques involve transforming the information to be learned in such a way that it is eventually associated with a picture or image. These associations have been found to be easier for students to use in attempting to remember information.

Safety

One of the most important instructionally-related concerns is making science instruction safe. Perhaps more than any other subject area in the curriculum, science requires a firm commitment to safety. Teachers should anticipate and prepare for potential problems. Some points to keep in mind:

1. Rules and procedures should be demonstrated, practiced, and reviewed regularly.

2. Dangerous materials (if needed) should be secured and labeled "off limits."

3. Eyes should always be protected.

4. Fire extinguishers should always be readily available.

5. Allow sufficient time to perform instructional activities to avoid problems associated with haste.

6. Special instructions are required if new and unfamiliar equipment or materials are being introduced.

7. Appropriate supervision is advised at all times.

Use of Microcomputers

The proliferation of microcomputer technology in classrooms can be observed throughout the nation. The excitement of this technology can be found in science classrooms as well. Table 3 reviews some of the ways in which microcomputers can be utilized in science programs. In addition, important considerations regarding the use of these different types of applications are provided.

Important uses of microcomputers include some of the following ideas:

1. Tutorials to expand upon various topics which may be confusing to special learners.

2. Performance of dangerous or risky experiments through the use of simulations.

3. Specific facts which are being studied can be entered into a database to help students organize and later retrieve information.

4. Commercial databases are available for some topical areas (e.g., different types of animals).

5. "Electronic" field trips are possible by way of communication software.

6. Probeware which is connected to the microcomputer directly can make, display, and record measurements.

Teachers should also be interested in how microcomputers can help them manage their classrooms more efficiently. Software is now available which can keep track of student performance and ultimately determine their grades. Other software allows teachers to generate IEPs, create instructional materials, plan lessons, develop tests, determine the readability of instructional materials, and establish databases which can be used to store many types of information.

Making Classrooms "Sciency"

One way to spice up the appearance of a classroom is to give it a science "feel." This idea can be followed even by teachers who do not teach science per se. Some of the ways to make a classroom "sciency" are obvious and traditional (e.g., bulletin boards with science themes) while others are unique and untraditional (e.g., vivarium with live reptiles). Without too much difficulty, learning centers can be established where students can conduct experiments. Library books with science themes can be obtained and placed in locations so that they can be examined and read. Animal collections can be started and put on continual display. Various science stations can be set up; for instance, students can record and graph the temperature, barometric pressure, and humidity on a daily basis. Pictures of everyday items taken at very close range or at an unusual angle (similar to those appearing

Table 3

Microcomputer Applications

TYPE OF USE	DESCRIPTION	FEATURES	CAUTIONS
Drill & Practice	Reinforces previously learned information and provides student with practice	*many students need extra practice *the more sophisticated program include graphics, animation, and sound *best used as adjunct to ongoing program	*can be overused *does not teach new concepts *best to have students work independently *avoid software that draws attention to students who make an incorrect response
Tutorial	Presents new or previously presented material, then assesses the student's understanding of the information	*additional instruction for those who need more time to grasp concepts *best used as adjunct to ongoing instruction	*not the most effective way of presenting new information to special learners *best to have students work independently
Simulation	Allows students to experience vicariously real-life events which are not easily shown in a traditional setting	*powerful *can provide more concrete examples of abstract concepts *realistic *very useful with students with limited experimental backgrounds *require participation *suitable for cooperative arrangements	*problems can arise if students do not possess prerequisite knowledge and/or skills *readibility may be too high *may have too many rules *best to use after some introduction and exposure to the topic *students may need help in generalizing computer-displayed events to real world

TYPE OF USE	DESCRIPTION	FEATURES	CAUTIONS
		*provide immediate feedback to personal/group decisions	*some simulation take too long best to use "stop-time"
		*motivating	simulations (i.e., one can stop and pick up again at a later time) (see Glenn & Rakow, 1985)
		*can substitute for certain dangerous situations (e.g., chemistry experiments with physically disabled students)	
Gaming	Combines learning and enjoyment by providing chancy situations to which students react	*can enhance socialization	*not much of this software relates directly to science or social studies
		*motivational	
		*can improve students on task behavior	*some students cannot handle (e.g., distractible, overactive, physically disabled)
		*practice manual dexterity	
		*adventure gaming requires problem solving skills	
Problem Solving	Use of the microcomputer to solve real-life problems--can include programming	*helps students understand problems and the processes needed to solve them	*may be too difficult
		*gives students an appreciation of how microcomputers can be helpful	*often requires teacher assistance and monitoring
Utility Applications	Use of microcomputers as an instructional tool for carrying out daily learning/life tasks word processing data management spreadsheets	*most students will need to know how to use these	*the more organized and simpler program and better
		*certain programs are extremely helpful to special learners (e.g., spelling checks, outlining programs)	*students will need to be taught how to use these programs directly

TYPE OF USE	DESCRIPTION	FEATURES	CAUTIONS
	communication graphics probeware misc. programs	*prepared databases are available (e.g., animals) *local networking is possible	*keyboarding skills may be a problem *students need to use these programs regularly to maintain performance
Interactive Video	Allow visual segments to be integrated interactively into computer-based instruction through the use of videodiscs and/or videotapes	*allow students to make choices about what they need *students can interact with the video segments *can be used with students of different abilities *provide realistic experiences--more so than computer-generated graphics *reduce the need to read *videodiscs can store large amounts of information	*videodiscs are expensive *limited availability of programs *some concepts can best be presented through other means (e.g., line drawings)

in Games Magazine) can be displayed. These ideas are only a few of many which are possible; the suggestion here is to encourage teachers to make classrooms engaging places to be.

Laboratory Materials and Equipment

Science activities very often require certain materials and equipment. Many of the programs described in this chapter come with the necessary items for accomplishing the proposed activities. Unfortunately, many of us have had to teach science with a bare bones operation, not having many available resources from which to choose. It is for this reason that a suggested list of common items is provided. This list (Table 4) is not an exhaustive one nor may it meet your personal needs perfectly. Nevertheless, it can serve as a guide for assembling a basis for teaching science. Obviously, for teachers of specific science topics at the secondary level, more sophisticated items may be indicated.

Suggested Resource Materials

Certain resource materials can assist in the planning and implementation of exciting science programs. This section will offer suggestions which are appropriate for teacher utilization as well as some materials which students can use.

Teacher Materials

Often teachers who conduct various science activities and cover different scientific topics want to know a little more about the concepts being addressed. Getting your hands on a sourcebook which does this may be advantageous. One such book for the elementary level is entitled A Sourcebook for Elementary Science (Hone, Joseph, & Victor, 1971)

A series of books which are full of good ideas for teaching science is the Brown Paper School Books published by Little, Brown and Company. Some of the titles include:

Beastly Neighbors: Or Why Earwigs Make Good Mothers
The Night Sky Book
Only Human: Why We Are the Way We Are
Blood and Guts: A Working Guide to Your Own Insides
The Reasons for Seasons
Gee Wiz! How to Mix Art and Science, or the Art of Thinking Scientifically

These books are stimulating and could even be used as a basis for developing your own customized program.

Teachers should also be aware of certain journals and periodicals which are valuable sources of research, current thinking, and instructional ideas. Some of these include:

Science and Children
Science Education
School Science and Mathematics
Journal of Research in Science Teaching
Science Teacher
American Biology Teacher

Table 4

Suggested Materials & Equipment
(Source: Polloway et al. (1989)

Common classroom items
1. cardboard
2. paper clips
3. popsicle sticks
4. razor blades
5. rubber bands
6. ruler
7. scissors
8. straight pins
9. tacks
10. tape (masking and regular)

Science related apparatuses
1. aquariums
2. balance, equal-arm
3. beakers, polyethylene
4. compass, magnetic
5. cylinder, graduated
6. dishes, petri
7. droppers, medicine
8. flasks (esp. 250 ml Erienmeyer)
9. funnels
10. hatchery/incubator
11. hot plate
12. microscopes and slides
13. models
14. nets, insect
15. pails
16. pipets
17. ring stand (with clamp and ring)
18. rubber stoppers
19. rubber tubing
20. small animal cages
21. test tubes
22. thermometers
23. tongs--"hot" utensil
24. wire gauze

Hardware equipment
1. garden spade
2. hammer
3. pliers (needle-nose)
4. screwdrivers (both types)

Materials from home and elsewhere
1. dish pans, rubber
2. film containers
3. jars
4. knives, forks, spoons
5. milk cartons
6. nails
7. #10 tin cans
8. plastic pitcher (large)
9. straws (paper and plastic)

Science-related materials
1. batteries, dry cell (1.5 volts, 6 volts, and flashlight)
2. battery holder for "D" battery
3. bell wire (insulated)
4. buzzer
5. candles
6. circuit switch
7. corks
8. filter paper (15 cm)
9. goggles, safety
10. light bulb recepticle
11. litmus paper
12. magnets (horseshoe and bar)
13. magnifiers, hand
14. prism

Chemicals
1. alcohol, rubbing
2. baking powder
3. baking soda
4. benedict's solution
5. cornstarch
6. flour
7. formaldehyde
8. gel
9. iodine
10. iron filings
11. lemon juice
12. limewater tablets
13. plaster of Paris (calcium sulfate)
14. salt
15. sugar
16. vinegar

Student Materials

There are two additional types of student-oriented materials of which teachers should be aware: trade books and student periodicals. Trade books are available on a wide range of science topics covering life, physical, and earth science. Cain and Evans state two good reasons for using these books: "Trade books provide children with additional sources of information. They often provide more motivation for the reluctant reader than does the textbook (1984, p. 156)." They also note that an up-to-date list of trade books is published every year in the journal Science and Children.

Students usually like to read magazines, and there are a few very good ones in the area of science. A selected list of some of the more popular ones follows:

3-2-1 Contact
National Geographic World
Your Big Backyard
Current Science
Ranger Rick

Another idea which can prove helpful is to capitalize on science topics which appear in other curricular materials. For instance, if basal readers are used, students are already reading the information and it might be advantageous to integrate some science activities that relate to the reading passage.

SUMMARY

This chapter on science instruction for special learners is designed and written to give teachers a glimpse at how this subject can be taught. Divided into two major parts, the chapter first reviewed what science education for special populations was all about and what was happening in special education classrooms in certain parts of the country. A brief examination of the limited literature bases was undertaken. In the second major section, practical information on teaching science in special settings was provided. Curricular content was discussed as were the different approaches to teaching science, highlighting the positive and negative features of each approach. Specific considerations concerning how best to implement science instruction were presented. Topics addressed included (a) conducting a science lesson, (b) integration of other subject/skill areas into science, (c) using learning strategies, (d) safety considerations, (e) microcomputer applications, (f) making classrooms "sciency", and (g) acquiring requisite laboratory equipment and materials. A principal goal of the chapter is to assert that teaching science can be exciting and valuable for both student and teacher.

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The book contains many activities, suggestions for obtaining resources, and other general information. It is a joy to read and can definitely stimulate thinking.

Corrick, M.E. (1981). Teaching handicapped students science: A resource handbook for K-12 teachers. Washington, D.C.: National Education Association.

This edited work contains 19 articles which suggest ways of helping special students in science. Perhaps its most outstanding feature is that there are a number of articles addressing needs at the secondary level.

Demanche, E.L. (1980. The Hawaii nature study program. Honolulu: Curriculum Research and Development Group, College of Education, University of Hawaii. (1776 University Avenue, Honolulu, HI 96822)

Although this is a program designed for use in Hawaii, it can and has been used in other areas of the country. It is fantastic. It contains four major topical areas: Small Animals, Insets, Plants, and Reef & Shore. The many hands-on ideas provide a great resource for developing science programs or activities that supplement already existing programs.

Stein, S. (1979). The science book. New York: Workman Publishing.

This book is another excellent teacher resource loaded with stimulating ideas. It suggests many different activities which most students should find interesting.

Stongin, H. (1976). Science on a shoestring. Menlo Park: Addison-Wesley Publishing.

How can you go wrong with a book whose title seems to epitomize the plight of most special educators who teach science. The major attraction of this resource is that it contains many activities which can be performed with everyday materials and equipment.